Beam Current Threshold For Coherent Emission and Its Dependence on Synchrotron Frequency

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The VUV ring has been found to emit coherent synchrotron radiation at millimeter wavelengths, due to a longitudinal instability of the bunched electrons. The instability occurs only when the beam current exceeds a threshold value that varies with the ring operating conditions. Such instabilities are expected to occur as a consequence of interactions between electrons inside a bunch. A modified form of the Keil-Schnell stability criteria (that takes into account a bunched beam) predicts a beam current threshold condition increasing with the momentum compaction α as $\alpha^{3/2}$, or as f_{so}^{3} (since $|\alpha| \sim f_{so}^{2}$ where f_{so} is the synchrotron frequency in the limit of zero beam current).

We have measured the threshold current for the instability while the VUV ring's lattice was adjusted to produce various values for the momentum compaction α. The synchrotron frequency f_{so} was measured for each case. The figure below shows the threshold current as a function of f_{so} on a log-log plot. The threshold increases as f_{so}^{3} for low beam currents, consistent with the proposed model. The changeover to f_{so}^{2} behavior at high beam currents is likely due to other factors (such as potential well distortion), which occur at high currents and are not included in the model.

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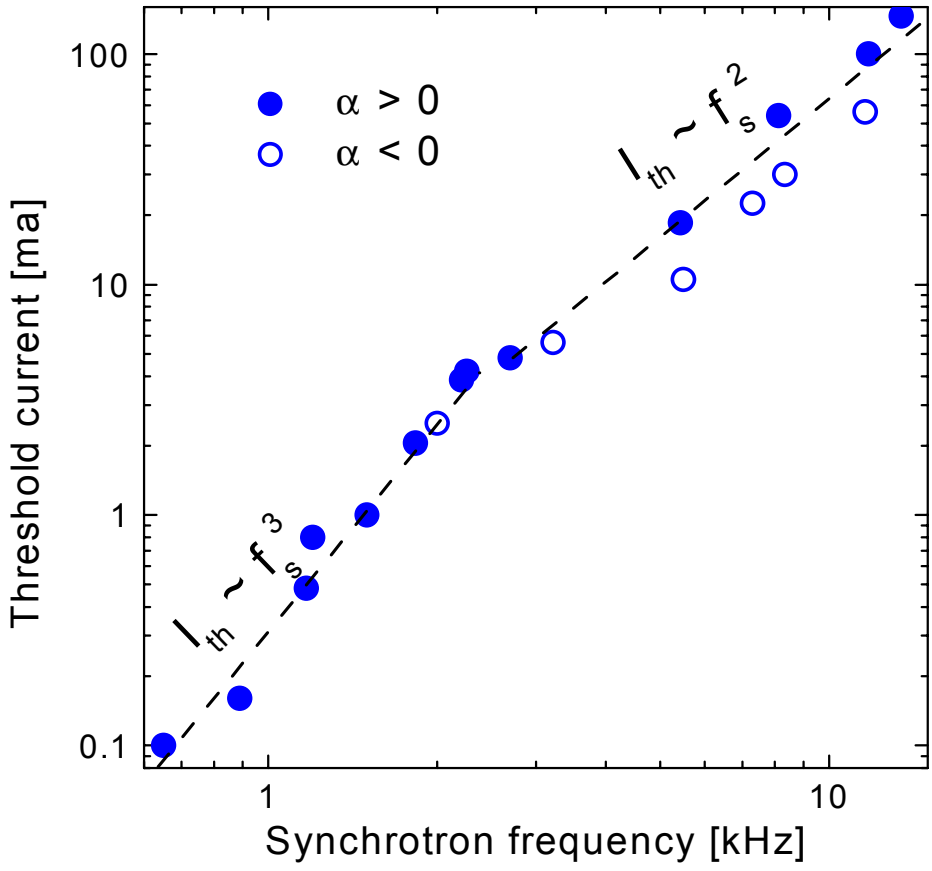

Figure 1. Beam current threshold for the coherent emission instability, as a function of the synchrotron frequency.